COMMERCIAL USE OF HIGH-CARBON FLY ASH IN CEMENT MANUFACTURING

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SUMMARY

Two commercial-scale demonstrations of the use of high-carbon fly ash in cement manufacture have been successfully performed. This paper describes the result from the initial demonstration. The concept has proven three critical benefits. First, new market for high carbon fly ash has been developed. High carbon fly ash, when used in this regard requires no preprocessing. Second, the fly ash replaces costly raw materials such as shale and clay normally used in as raw materials in cement manufacture. Finally, the high carbon content conserves energy by serving as a partial fuel substitute in the energy-intensive cement manufacturing operation.

Nearly 65 million tons fly ash is annually produced in the U.S., of which only one third is used in commercial products. The majority of the fly ash that is generated is landfilled. With the impending regulatory pressure to reduce emissions at coal-fired power plants, production of more fly ash with significantly higher carbon contents is imminent. Since high carbon fly ashes are undesirable for use in concrete, the urgency for alternate reuse applications is growing.

In each of the highly successful demonstrations, a large quantity of high-carbon fly ash was procured from Ameren's Power Station in Coffeen, Illinois, and used in a nearby cement plant. The cement plant utilizes preheater kiln system.

Prior to its use, the ash was analyzed for chemical composition and evaluated for its compatibility with raw materials from the cement plant. The analysis of the fly ash confirmed its compatibility with the normally used raw materials. A high L.O.I. (>20%) suggested the presence of a large quantity of fuel energy. The fuel value of the fly ash was in excess 318 Btu/lb.

At the cement plant, the fly ash was interground with the other raw materials and introduced into the manufacturing process in a normal manner. The raw materials were then normally processed in to clinker (an intermediate product). The resulting clinker was ground in the finish mills with gypsum to produce portland cement. Both the clinker and cement were characterized and compared to those normally produced at the plant. During the demonstration several key parameters on the aspect of material processing, operation, and product performance were also observed.

Although the intent was to maximize the use of fly ash in the raw mix, fluctuations in the chemistry of the other raw materials limited the average addition of fly ash to 6% of the raw mix. The fly ash, however, replaced a majority of the shale in the raw mix.

During the preheating stage, the temperatures of the lower preheater stages rose significantly primarily because of the thermal contribution of carbon in the fly ash. This resulted in nearly 30% additional calcination of the raw feed. Typically, an improved calcination facilitates burning, conserves fuel, and improves clinker production. Also, the material flow within the preheater cyclones was smooth and plug-free, because of the reduced exit pressures.

An increase in kiln feed rate was also noted which can be attributed to high carbon that had caused an increased calcination of the raw feed. Increased kiln feed rate resulted in 10% improvement in clinker production. Furthermore, fuel supply during the demonstration was also reduced to adjust for the energy provided by carbon in the fly ash. The resulting energy reduction was nearly 4%, which corresponded to a significant saving of over 90,000 Btu/ton of clinker.

Characterization of the demonstration clinker confirmed the presence of major clinker phases. Likewise, the demonstration cement conformed to both the chemical and physical requirements of ASTM C 150 specifications. Of interest is the reduced alkali content of cement without any equipment modifications. Low alkali cements are always preferred in concrete for improved durability. The compressive strength of cement was comparable to cement produced before to and after the demonstration. In fact the 28-day strength for cement made during the demonstration improved, which can potentially produce higher strength concrete.

This technology offers a large-scale consumption of high-carbon fly ash that can translate to improved economics to the utilities as well as to the cement manufacturers.